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Home oxygen therapy from the emergency department for COVID-19 an observational study

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ABSTRACT

Study objective: During the COVID-19 pandemic, prescribing supplemental oxygen was a common reason for hospitalization of patients. We evaluated outcomes of COVID-19 patients discharged from the Emergency Department (ED) with home oxygen as part of a program to decrease hospital admissions.

Methods: We retrospectively observed COVID-19 patients with an ED visit resulting in direct discharge or observation from April 2020 to January 2022 at 14 hospitals in a single healthcare system. The cohort included those discharged with new oxygen supplementation, a pulse oximeter, and return instructions. Our primary outcome was subsequent hospitalization or death outside the hospital within 30 days of ED or observation discharge.

Results: Among 28,960 patients visiting the ED for COVID-19, providers admitted 11,508 (39.7%) to the hospital, placed 907 (3.1%) in observation status, and discharged 16,545 (57.1%) to home. A total of 614 COVID-19 patients (535 discharge to home and 97 observation unit) went home on new oxygen therapy. We observed the primary outcome in 151 (24.6%, CI 21.3–28.1%) patients. There were 148 (24.1%) patients subsequently hospitalized and 3 (0.5%) patients who died outside the hospital. The subsequent hospitalized mortality rate was 29.7% with 44 of the 148 patients admitted to the hospital dying. Mortality all cause at 30 days in the entire cohort was 7.7%.

Conclusions: Most patients discharged to home with new oxygen for COVID-19 safely avoid later hospitalization and few patients die within 30 days. This suggests the feasibility of the approach and offers support for ongoing research and implementation efforts.

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1. Background

The COVID-19 pandemic placed a burden on the United States healthcare system with peaks of up to 160,000 simultaneously hospitalized patients and over 1,100,000 deaths thus far [1]. The majority of COVID-19 illness is mild or moderate and requires limited medical therapy for recovery [2].

Oxygen supplementation is one of the most common therapies during hospitalization for COVID-19 [3,4]. Because many patients require only supplemental oxygen until recovery, and since oxygenation monitoring is readily available outside the hospital, home oxygen therapy is an alternative to hospitalization that could reduce the overall stress on hospital capacity and allow recovery at home, both attractive options. Home oxygen therapy reduces hospitalization in children with RSV [5],

but there are few data and no trials about the feasibility and safety of home oxygen for acutely hypoxic adults with COVID-19.

In response to the rapid demand for healthcare services, our healthcare system developed an ED-initiated home oxygen program for COVID-19 patients. We anticipated that most patients receiving home oxygen therapy would recover with few progressing to hospitalization or death. This study aims to document the primary outcome of subsequent hospitalization or death outside a hospital for patients enrolled in our discharge with home oxygen program to inform current and future efforts on patient care during events that stress healthcare resources.

2. Methods

2.1. Study design

We retrospectively examined patients discharged from 14 hospitals in a single Pennsylvania healthcare system from April 2020 to January 2022 in accordance with STROBE reporting guidelines for observational

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studies [6]. The University's Human Research Protection Office Institutional Review Board approved a waiver of informed consent to review these medical records. One emergency physician and one research assistant manually abstracted data by electronic health record (EHR) chart review. Chart reviewers were not blinded to the purpose of the study. We performed cross-review on 6% of charts and found a Cohen's Kappa of 0.9 and 95% agreement between abstractors. All data was stored in a secure REDCap database [7].

2.2. Study population

We included patients aged 18 years and older discharged with a new order of home oxygen therapy following ED or observation visit for COVID-19 respiratory illness – identifying these patients by a systemwide record of Durable Medical Equipment (DME) orders and associated ICD coding. We adjudicated Covid-19 respiratory illness by reviewing EHR documentation and diagnostic tests. We recorded in-system PCR SARS-CoV-2 testing, patient reported out-of-system testing and clinician diagnosis by history. We excluded any people on chronic oxygen therapy, persons lacking a diagnosed COVID-19 infection (diagnosis of infection either per history and exam, patient-reported outside testing, or in-system SARS-CoV-2 testing), or if home oxygen was unrelated to COVID-19.

2.3. Outcome measures

The primary patient outcome was death outside the hospital or hospitalization within 30 days determined by EHR records of return ED visits or hospitalizations, outpatient visits, ensuing surgeries or procedures, external laboratory or imaging results, pharmacy filled prescriptions, and review of online obituaries. We considered patients to be alive without hospitalization from COVID-19 if there was documented resolution of respiratory symptoms, discontinuation of oxygen therapy or completion of the telehealth monitoring program even if data beyond 30 days was absent. We reported on patient deaths after transitioning to hospice care within 30 days of ED discharge but excluded this from our primary outcome. We determined that home oxygen use in hospice transition preserved inpatient healthcare resources while allowing patients to pursue medical therapies that most aligned with their values. Enrolling in hospice provided evidence that the patient had adequate time and re-evaluation outside the hospital such that they could have returned for hospital admission if patients and/or family desired. We defined lost-to-follow-up as those having an index visit without subsequent EHR data points or reported death by online obituary during final EHR review. Complete follow up occurred by experiencing the primary outcome or having evidence of living without a primary outcome at 30 days. We analyzed the data without imputation.

2.4. Home oxygen program overview

Clinicians independently determined individual patient appropriateness for discharge with home oxygen absent any imposed or protocolized treatment guidelines (as none existed early in the pandemic). The healthcare system sent scheduled reminders to all physicians to consider home oxygen as an alternative. The DME supplier provided services Monday to Friday from 8 AM to 6 PM and Saturday to Sunday from 8 AM to 4:30 PM. EDs either provided an oxygen cylinder on discharge with planned DME delivery for patients treated outside usual hours of operation or placed patients in observation units until assured home oxygen delivery. All EDs discharged patients with a personal home pulse oximeter and return guidelines provided by the treating physician. Primary care or other treating physicians and advanced practice providers assumed follow up for patients after discharge. The system provided an option for scheduled tele-health follow up or daily at home tele-health monitoring programs based on availability and physician discretion.

2.5. Data collection

We collected the total number of ED patients evaluated for COVID-19 by an EHR query using ICD-10 code U07.1 for COVID-19 illness. The query noted the disposition of ED patient encounters as admission, placed in observation, or ED discharge. We used the total number of patients admitted plus the addition of our home oxygen discharge cohort as a denominator. We then used the number of home oxygen discharges without subsequent hospitalization from our cohort as a numerator divided by the denominator to evaluate the impact home oxygen discharges had on COVID-19 hospital admissions.

We collected data from our inpatient and outpatient electronic records, identical across our system. We supplemented internal data with external shared records found in the Pennsylvania CommonWell network Health Information Exchange, EPIC Care Everywhere and online obituaries [8,9]. We collected patient demographics and comorbidities from the EHR. We defined immunosuppression as those with human immunodeficiency virus, active hematologic or solid organ cancer, organ transplant on antirejection medication, chronic steroid use, immune-mediated inflammatory disorders, and patients receiving chemotherapy or immunomodulating drugs. Cancer history included any history of cancer or active cancer. Reviewers abstracted vital signs from the EHR for the initial ED visit. When only one set of recorded vital signs existed, these were used as both admission and discharge values.

We collected imaging results from the initial ED episode. We classified results “abnormal” if radiologist interpretation included evidence of opacities, infiltrates, ground glass, airspace disease or reported an inability to rule out, suspicion, consistent, or indication of pneumonia. We documented newly prescribed COVID-19 therapies (steroids, antibiotics, and anticoagulation) from the discharge clinical summary document. The system guidelines recommended against outpatient antiviral and monoclonal antibodies for patients receiving oxygen therapy and remdesivir was not available as an outpatient infusion; we did not collect data on these outpatient therapies for this reason. We counted pre-existing patient prescriptions for COVID-19 therapies as an ED discharge therapy if the ED physician noted the prior prescription as a reason not to provide a prescription in their medical decision making.

2.6. Statistical analysis

We report primary data as count, frequencies, ranges, and rates. We report our variables as median and interquartile ranges (IQR) since there were no normally distributed variables. STATA SE v16.1 was used to perform statistical analysis.

3. Results

Among 28,960 patients evaluated for COVID-19 at the 14 EDs during the study period, providers admitted 11,508 (39.7%) to the hospital, placed 907 (3.1%) in observation units, and discharged 16,545 (57.1%) directly home. Among those discharged home, 632 had new home oxygen therapy: 535 from the ED after a median of 6.3 h (IQR 4.6, 8.8), and 97 from an observation unit after a median of 21.8 h (IQR 18.8, 26.8). Eighteen (2.8%) patients were lost-to-follow-up. We analyzed outcomes for 614 (97.2%) patients with complete follow up.

The demographics and comorbidities for the 614 patients are listed in Table 1. ED index visit characteristics are listed in Table 2 and radiographic results are detailed in Table 3. EDs confirmed COVID-19 illness by PCR testing for 302 (49.2%) patients, and 296 (48.2%) patients had a patient-reported positive COVID-19 test prior to ED visit. Physicians diagnosed COVID-19 clinically in 16 (2.6%) patients by history and exam without testing. One patient had a segmental pulmonary embolism detected among 140 Chest Computed Tomography scan with contrast.

Table 1
Cohort Demographics with Breakdown by Primary Outcome.

	Total (N = 614)		Primary Outcome (N = 151)		No Primary Outcome (N = 463)	
	Median	IQR	Median	IQR	Median	IQR
Age	61.4	50.3, 71.4	64.9	55.0, 74.5	60.2	49.5, 70.0
Gender	N	%	N	%	N	%
Male	331	53.9%	87	57.6%	244	52.7%
Female	283	46.1%	64	42.4%	219	47.3%
Race	N	%	N	%	N	%
White	558	90.9%	132	87.4%	426	92.0%
Black/African	33	5.4%	12	8.0%	21	4.5%
Asian	4	0.7%	2	1.3%	2	0.4%
American Indian	1	0.2%	1	0.7%	0	0.0%
Native Hawaiian	0	0.0%	0	0.0%	0	0.0%
NA	18	2.9%	4	2.7%	14	3.0%
Comorbidities	N	%	N	%	N	%
Hypertension	304	49.5%	83	55.0%	221	47.7%
Diabetes	120	19.5%	26	17.2%	94	20.3%
Heart Failure	26	4.2%	8	5.3%	18	3.9%
CAD	42	6.8%	15	9.9%	27	5.8%
CVA/TIA	30	4.9%	4	2.7%	26	5.6%
Asthma	87	14.2%	20	13.3%	67	14.5%
COPD	48	7.8%	10	6.6%	38	8.2%
CKD	17	2.8%	5	3.3%	12	2.6%
ESRD	1	0.2%	0	0.0%	1	0.2%
Cancer Hx	62	10.1%	19	12.6%	43	9.3%
Immunosuppressed	31	5.1%	15	9.9%	16	3.5%

N = Number of Patients, % = Percentage of Patients, IQR = Interquartile Range, NA = not available, CAD = Coronary Artery Disease, CVA = Cerebrovascular Accident, TIA = Transient Ischemic Event, COPD = Chronic Obstructive Pulmonary Disease, CKD = Chronic Kidney Disease, ESRD = End Stage Renal Disease.

Table 2
ED Index Visit Characteristics with Breakdown by Primary Outcome.

	Total (N = 614)		Primary Outcome (N = 151)		No Primary Outcome (N = 463)	
	Median	IQR	Median	IQR	Median	IQR
Vital Signs						
Triage RR	20	18, 22	20	18, 22	20	18, 22
Disch RR	19	18, 22	20	18, 22	19	18, 21
Disch O2%	95	93, 96	95	93, 96	95	93, 96
Disch LPM	2	0, 2	2	2, 2	2	0, 2
SpO2/FiO2	331	317, 424	328	303, 341	331	321, 433
Lowest O2%	89	88, 91	89	88, 91	89	88, 91
BMI	32	27.4, 37.9	32.7	26.9, 38.2	32.0	27.7, 37.8
Symptoms (d)	8	6, 11	7	5, 10	8	6, 11
Visit Type	N	%	N	%	N	%
Emergency	519	84.5%	126	83.4%	393	84.9%
Observation	95	15.5%	25	16.6%	70	15.1%
Discharge Medications	N	%	N	%	N	%
Steroids	318	51.8%	79	52.3%	239	51.6%
Antibiotics	45	7.3%	12	8.0%	33	7.1%
Anticoagulation	4	0.7%	0	0.0%	4	0.9%

N = Number of Patients, % = Percentage of Patients, IQR = Interquartile Range, Disch = Discharge, RR = Respiratory Rate, O2% = Peripheral Oxygen Saturation, LPM = Liters Per Minute, BMI = Body Mass Index, (d) = Days.

The primary outcome occurred in 151 (24.6%, CI 21.3–28.1%) patients in the cohort: 148 (24.1%) were hospitalized and 3 (0.5%) died outside the hospital. Separately, two patients (0.3%) died in hospice following ED discharge, one after three days and the other after nine days. There were 461 patients (75.1%) who recovered without requiring

subsequent hospitalization or experiencing death within 30 days of ED home oxygen discharge. All patient outcomes following ED index visit discharge are listed in [Table 4](#). The 148 patients who returned and were admitted spent a median of 3 days (IQR 2, 5) outside the hospital. Their median Hospital Length of Stay was 8 days (IQR 5, 15). The

Table 3
ED Index Visit Radiography with Breakdown by Primary Outcome.

Radiology	Total (N = 614)			Primary Outcome (N = 151)			No Primary Outcome (N = 463)		
	N	%	N Abn (%)	N	%	N Abn (%)	N	%	N Abn (%)
None	24	3.9%	–	4	2.6%	–	20	4.3%	–
CXR	439	71.5%	339 (77.2%)	117	77.5%	95 (81.2%)	322	69.5%	244 (75.8%)
CT Chest	151	24.6%	136 (90.1%)	30	19.9%	27 (90%)	121	26.1%	109 (90.1%)

N = Number of Patients, % = Percentage of Patients, N Abn (%) = Number of Abnormal Studies and Percentage, CXR = Chest Radiograph, CT Chest = Computed Tomography of the Chest.

Table 4
Primary Outcomes and Composite Breakdown.

Outcomes	N = 614	%
Primary Outcome	151	24.6%
Hospitalization	148	24.1%
Death	3	0.5%
Recovery	461	75.1%
Hospice	2	0.3%

Legend: N = Number of Patients, % = Percentage of Patient.

Table 5
Admitted Outcome Characteristics.

Characteristic	N = 148	%
HHFNC/NIPPV	85	56.7%
ICU	60	40.5%
IMV	33	22.3%
ECMO	1	0.7%
Mortality	44	29.7%
	Median	IQR
Hosp LOS	8	5, 15
ED to Admit (d)	3	2, 5

N = Number of Patients, % = Percentage of Patients, HHFNC/NIPPV = Heated High Flow Nasal Canula or Non-Invasive Positive Pressure Ventilation, ICU = Intensive Care Unit, IMV = Invasive Mechanical Ventilation, ECMO = Extra-Corporeal Membrane Oxygenation, Hosp LOS = Hospital Length of Stay, (d) = Days.

mortality rate of those admitted to the hospital was 29.7% with 44 patients dying. The cohort's overall mortality rate was 7.7% with 44 (7.2%) patients dying after hospitalization and 3 (0.5%) patients dying outside the hospital. Outcomes and therapies for patients with subsequent hospitalization are listed in Table 5. The index visit characteristics for ED discharge compared to observation discharge are provided in Table 6.

4. Discussion

Our experience shows it is possible to create and implement an ED-based new home oxygen therapy pathway for COVID 19 patients, and the crude safety signals were not distressing. Most (75.1%) patients provided new home oxygen from the ED recovered outside the hospital with supportive care. For comparison, Terp et al. expanded on the Banerjee et al. study to report on 360 ED patients discharged from a single center with pulse oximetry, home oxygen and telemedicine follow up. Their study found a rate of 15.8% 30-day unscheduled hospitalization due to COVID-19 with one patient dying without evidence of

Table 6
ED Index Visit Characteristics by Visit Type.

Emergency	N = 535	%	Observation	N = 97	%
Primary Outcome	126	23.6%	Primary Outcome	25	25.8%
Vital Signs	Median	IQR	Vital Signs	Median	IQR
Triage RR	20	18, 22	Triage RR	20	18, 22
Disch RR	19	18, 22	Disch RR	18	18, 20
Disch O2%	95	93, 96	Disch O2%	94	93, 96
Disch LPM	2	0, 2	Disch LPM	2	2, 3
Lowest O2%	89	88, 91	Lowest O2%	89	87, 91
BMI	32	27.3, 37.8	BMI	31.6	28.4, 38.2
Symptoms (d)	8	6, 10	Symptoms (d)	8	5, 12

N = Number of Patients, % = Percentage of Patients, IQR = Interquartile Range, Disch = Discharge, RR = Respiratory Rate, O2% = Peripheral Oxygen Saturation, LPM = Liters Per Minute, BMI = Body Mass Index, (d) = Days.

being hospitalized at the time. These rates are lower than our reported rates of 24.1% 30-day hospitalization and 0.5% known to die outside a hospital. The findings in this paper do fall within the confidence intervals of the worst-case sensitivity analysis performed by Terp et al. Our study describes a cohort that is older, with a median age of 61.4 years compared to 51 years old, with more hypertension and less diabetes. We also reported on patients from 14 different EDs including non-urban centers where access to healthcare may vary from a single urban center [10,11].

The differences in our findings, compared to the Terp et al. study, may be related to their study having a set clinical pathway with criteria for enrollment and dedicated telephone follow up after discharge. Telemedicine was available at certain centers within our study but was not provided to every patient. Support for telemedicine was observed in a Guadeloupean study finding subsequent hospital admission rates of 4.8% and 20% respectively when ED patients discharged with home oxygen were followed by a dedicated COVID-19 telehealth team as compared to usual care [12]. Similarly, a study in the Netherlands found a 30-day hospital admission rate of 15.9% from a small single center cohort of ED patients discharged with telemonitoring on less than 3 l of supplemental oxygen [13]. A separate study reported a hospital admission rate of 12.7% within 7 days of ED discharge for severe COVID-19 with virtual follow-up. Almost a quarter of these patients were provided home oxygen for exertional hypoxia defined as SpO2 90–91% during a 1-min walk [14]. Nonetheless, revisiting an ED or later admission alone is not a strong safety concern unless linked to other missed care opportunities.

Our study is not able assess the potential benefits or risks conferred to patients if they had been hospitalized to receive inpatient care versus discharge with home oxygen. Our cohort's overall mortality was 7.7%, lower than some other reported inpatient mortalities ranging from 10.8%–13.6% [15,16]. It is higher than higher than the 1.4% overall 30-day mortality rate found by Terp et al. but our cohort and implementation of home oxygen pathway are decidedly different [10]. Our lower outpatient mortality rate, compared to reported in-hospital mortality, could be the result of ED physicians selecting a relatively healthier cohort, but could also be associated with avoiding inpatient harms [17,18]. Discharged patients that were subsequently admitted experienced a relatively high eventual mortality rate of 29.7%, clearly in part evidence of a sicker subpopulation. It is unknown if inpatient monitoring and earlier escalation of care would have impacted these patients' outcome.

Many patients had oxygen prescribed absent recorded hypoxemia. Additionally, some of these patients were not receiving oxygen therapy during their ED or observation visit. We cannot know why clinicians decided home oxygen therapy was indicated for these patients. However, clinician gestalt likely drove home oxygen prescribing in such cases, as the primary outcome was met in 19.3% of those patients with normoxia without in-ED supplemental oxygen recorded at discharge and 25.5% with recorded in-ED supplemental oxygen.

We carefully assessed all patients in our cohort dying within 30 days after ED care. There were only three patients who died outside the hospital without returning for care. One patient was evaluated by an internal medicine team in the ED who recommended discharge since the patient was not requiring oxygen during ED evaluation or at discharge. Another patient awaited a bed for 38 h before electing discharge with two liters home oxygen, subsequently dying within 24 h of discharge. The final patient died following a 50-h observation visit and discharge with two liters oxygen to continue recovery at home. Our chart review of these cases did not find any clinical care concerns that could have been acted on to avoid death. Two patients entered hospice following home oxygen discharge dying three and nine days after ED discharge. Discharge with oxygen was potentially in the best interest of these two patients as it likely provided additional time with family in a familiar environment prior to death, in accordance with the care and values these patients sought.

Our findings provide additional perspective on a unique cohort that has not been extensively studied since home oxygen therapy has not been a common discharge therapy from the ED. We estimate that 4% of expected hospitalizations were avoided using the program assuming patients discharged with new home oxygen would have otherwise been admitted. This may underestimate the achievable impact as new practice patterns take time for wide adoption among providers. Even small reductions in admissions have an important impact on ED and hospital overcrowding. Home oxygen therapy is an important tool for future COVID-19 surges and other respiratory pandemics. We believe our findings support the need for further investigation into the impact of ED home oxygen prescribing on patient outcomes and healthcare utilization.

4.1. Limitations

Our study is limited by the observational retrospective nature based on electronic medical record review. Our findings may not be generalizable as we reported on an overwhelmingly white (90.9%) cohort, aligned with racial demographics of the included regions. [19] Data on the vaccination status of patients was not available, which could have an impact on the likelihood of our primary outcome. Lastly, the standards of care during the pandemic varied based on regional prevalence and resources as well as secular trends.

5. Conclusion

Home oxygen therapy is feasible for COVID-19 patients after emergency department discharge and later admission is low while death at 30-days is very low. The safety and feasibility of this practice will likely increase as advances in home monitoring and telehealth continue to progress. The addition of home oxygen to accepted outpatient COVID-19 therapies is another tool to relieve healthcare system overcrowding as it appears COVID-19 may persist longer than initially suspected.

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Meetings

Andrew Schoenling presented a poster on a proportion of the cohort prior to final data collection. The poster was presented at the Society of Academic Emergency Medicine New Orleans, May 2022.

Author contributions

Andrew Schoenling conceived of the study, obtained IRB approval, collected the data, performed statistics, and wrote the manuscript. Adam Frisch, Alex Weissman, Clifton Callaway, and Donald Yealy guided the study design, assisted in acquisition of data, provided interpretation of the data, revised the manuscript, and approved the final version.

CRediT authorship contribution statement

Andrew Schoenling: Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Adam Frisch:** Writing – review & editing, Resources, Data curation. **Clifton W. Callaway:** Writing – review & editing, Supervision, Methodology, Formal analysis. **Donald M. Yealy:** Writing – review & editing, Supervision, Formal analysis. **Alexandra Weissman:** Writing – review & editing, Supervision, Project administration, Methodology, Formal analysis, Conceptualization.

Conflicts of interest

None of the authors have conflicts of interest to report in relation to this research project.

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